Automotive PEM Fuel Cell System Development at AlliedSignal

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AlliedSignal is developing a 50-kW, high efficiency PEM fuel cell stack system for use in light-duty vehicle transportation under sponsorship from the Department of Energy(DOE)and the South Coast Air Quality Management District. The fuel cell stack system (FCSS) is to run on a hydrogen-rich reformate typical of that from a fuel-flexible fuel processor under separate development by the DOE. The FCCS includes heat, water, and thermal management of the entire fuel cell engine system but excludes fuel processing and delivery.

Program Overview

AlliedSignal is to research, develop, assemble, and test a 50-kW PEM FCSS comprised of a PEM fuel cell stack and the supporting gas, thermal, and water management subsystems. The program deliverable is a brassboard 50-kW PEM fuel cell stack system to Argonne National Laboratory at the conclusion of the 33-month project duration.

DOE Targets

While PEM fuel cells are promising alternatives to the internal combustion engine (ICE) due to their cleanliness and efficiency, they will not experience wide spread use in light-duty automotive applications until the FCSS cost is comparable to that of the ICE. In order to accelerate the adoption of PEM fuel cell technology, AlliedSignal is developing PEM stack technology and system designs that are substantially more efficient than the ICE and comparable in cost, weight, and volume. The DOE targets are shown below:

Metric	**DoE 2000 Targets**
System Efficiency at Peak Power (50kW-Net)	44%
System Efficiency at Nominal Power (12.5kW-Net)	55%
Net Power Density	350 W/liter
Net Specific Power	350 W/kg
System Cost (500,000 units/year)	$100/kW
Emissions	<Tier 2
Transient Performance (10-90% Power)	3 seconds
Cold Start-up to 50kW-Net	5 min(–40ºC), 1 min(20ºC)

Approach

A conceptual system design effort was performed in order to define a FCSS with potential of meeting the DOE goals. The effort includes system definition, system modeling, component designs, cost estimation, and comparison to DOE goals. With R&D projects, this is an iterative process as initial system component performances must be adjusted after design; in addition, system configuration and component requirements may be revised in order to meet the DOE system goals. Trade studies are performed to further define and characterize the system.

Conceptual Design

A design has been identified that has the following characteristics:

- Utilizes a turbocompressor for air management
- Recovers condensate from the stack exit and plant exhaust for fuel processor and fuel cell stack requirements
- Utilizes a pressurized stack(3-atm) at peak loads; at average and below average loads, the system operates at near ambient conditions (1.25 atm).

Efficiencies, weight, and volumes are compared to the DOE goals:

Metric	**DoE 2000 Targets**	**Projections**
System Efficiency at Peak Power (50kW-Net)	44%	44%
System Efficiency at Nominal Power (12.5kW-Net)	55%	55%
Volume, liters	143 (350 W/liter)	177 (=summed parts)
Weight, kg	143 (350 W/kg)	169

The basic performance features of the conceptual system will be demonstrated in a brassboard system as the project deliverable.

Technology Gaps

The conceptual design identified that an improvement in fuel cell stack performance is required to increase the voltage and hydrogen utilization on gasoline-based reformate in order to meet efficiency, weight, and volume goals. A preliminary cost estimate indicated that the balance-of-plant items could cost $40/kw; hence, the cost goal for the fuel cell stack is $60/kw to meet the DOE 2000 cost goal of $100/kw for the FCCS.